



Foraminifers and their use in environmental assessment

Field Trip Guide

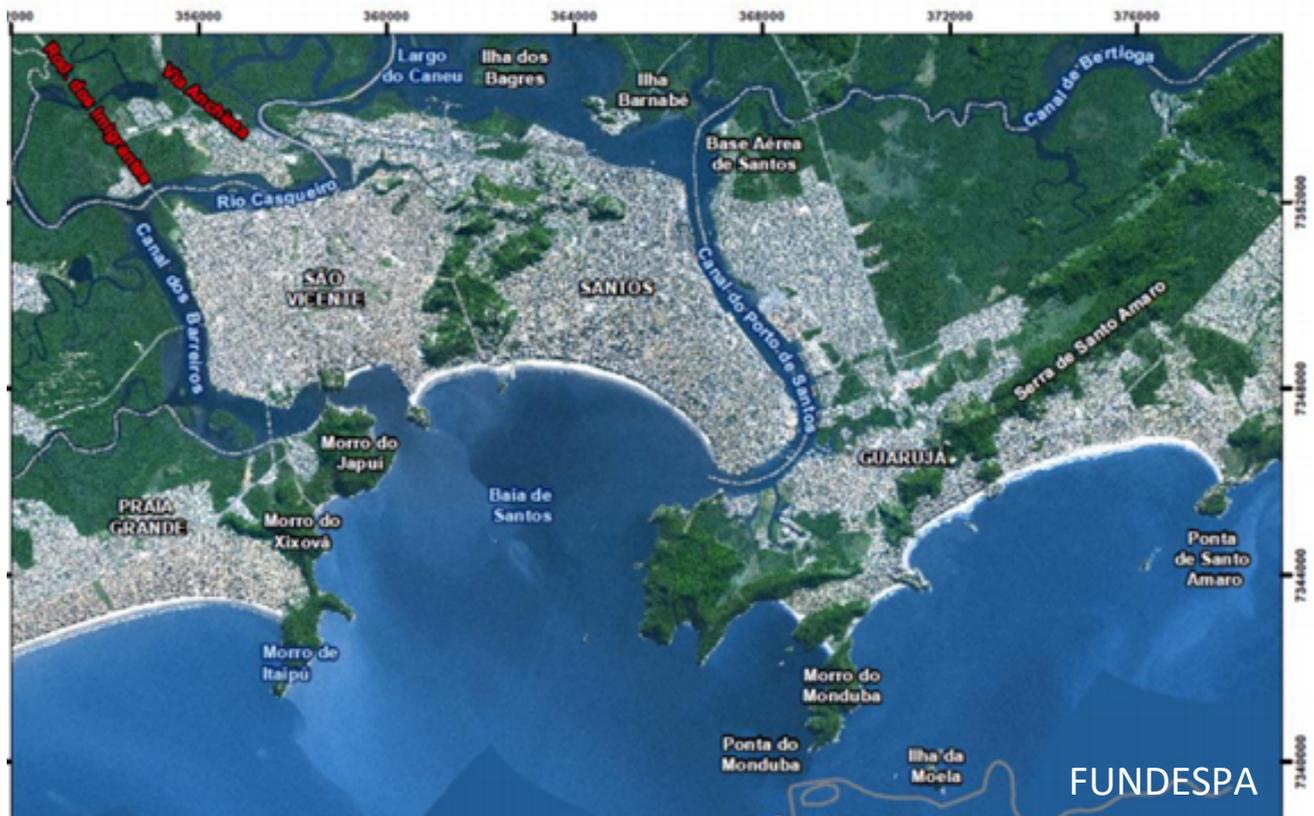
Santos Estuarine Complex

The one-day field trip is a visit to the Santos estuarine complex, around 70 km from São Paulo city. The Santos estuarine complex is located in the central portion of São Paulo State's coast (SE Brazil) and consists of three main estuarine channels: Santos (harbor); São Vicente and Bertioga channels. Residual fluxes in the system indicate residual transport to inside of the estuary in Santos channel, and towards to the ocean in the other two channels. The channels constitute the more dynamic regions in the estuary, while the upper estuary, with its low dynamics and more time of residence, it is a place of deposition of pollutants. The Santos estuarine area is heavily occupied by urban, industrial and port activities holding the largest port and the largest industrial complex of the Brazilian coast, the Cubatão industrial pole, which includes a petroleum refinery and petrochemical and metallurgical complexes. Santos harbor activities account for the movement of almost one-third of Brazilian trade. In order to keep its navigation depth, the Santos channel is dredged to about 15 m, starting in the Santos bay up to about 6 km up estuary. The São Vicente and Bertioga channels present depths of about 5 m.

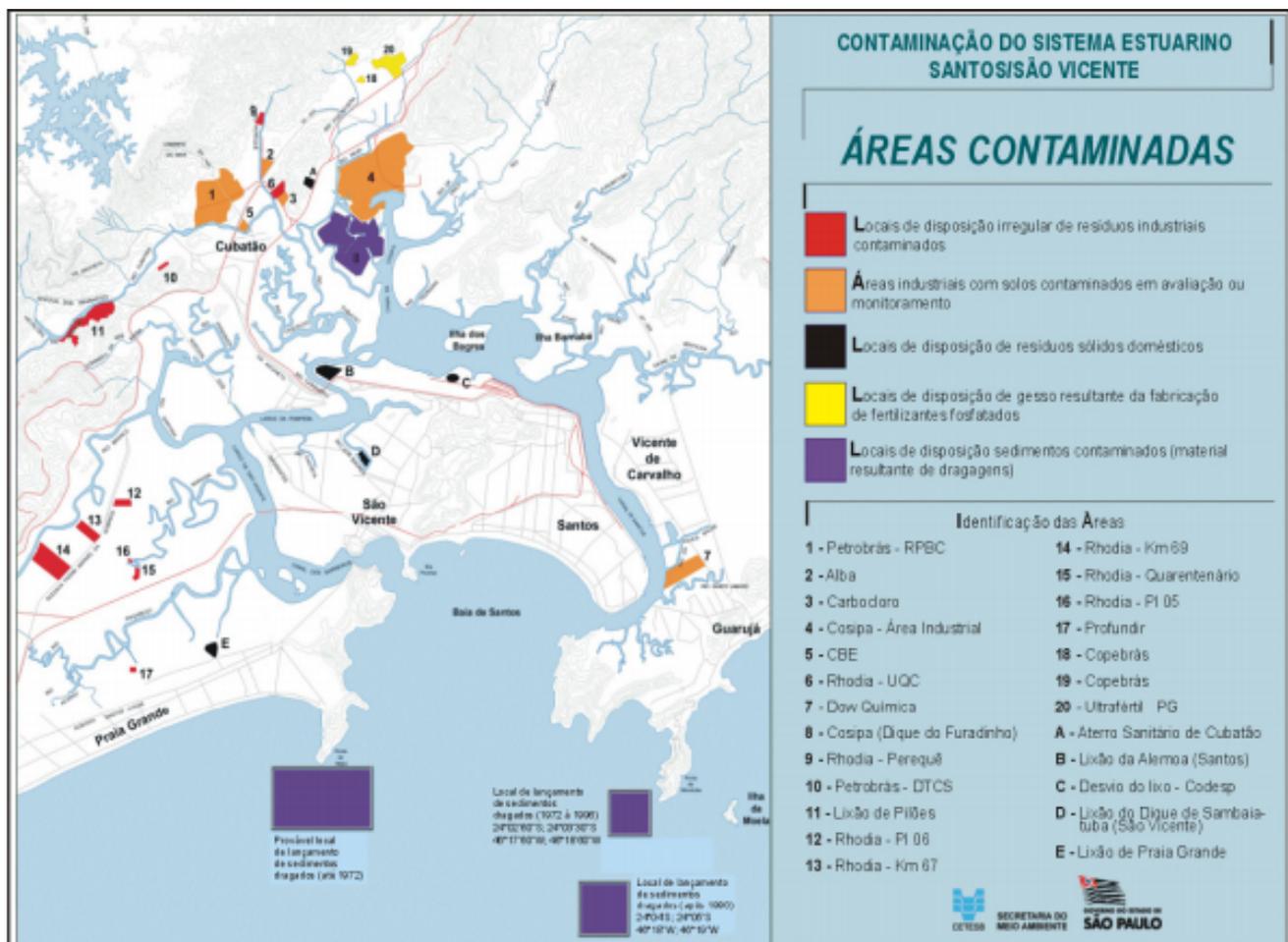
The metropolitan area where the Santos estuary is located, known as Baixada Santista, has an area of about 120 km² of mangrove forest, accounting for 52% of the total in São Paulo State. More than 70% of the Baixada Santista is classified as protected in an attempt to preserve remnant areas of the threatened Atlantic Forest and conserve the mangroves of the Santos estuary (PSMC, 2006). Around 40% of the forest is well preserved, mostly in the Bertioga region and in some parts of São Vicente.

Santos Estuary receives a high load of organic and inorganic contaminants from the diversity of local human activity. The port of Santos activities, such as constant ship traffic, cleaning operations of cargo and water ballast tanks and basements, and garbage and sewage production from docks and ships release of a large number of pollutants. Additionally, there are the dredging of the historically contaminated sediments of the Santos and Piaçaguera channels, domestic sewage, garbage dumps and landfills from a permanent population of over 1,200,000 settled in the cities of Santos and São Vicente (Souza et al. 2018). The urban waste water of Santos and São Vicente is mainly discharged through a submarine outfall located at the centre of the bay that connects the system with the Atlantic Ocean.

The benthic foraminifera communities of the estuarine complex present different characteristics. Assemblages located in the Santos Bay and Santos channel exhibit higher density, richness, and diversity values compared to the upper estuary regions. *Ammonia* is the most dominant genus in the system, mainly in the upper estuary. In the Santos Bay and Santos Channel, *Pararotalia cananeaensis*, *Pseudononion japonicum* and *Criboelphidium* spp. are also observed.



Áreas contaminadas na região do estuário de Santos e São Vicente (CETESB, 2001)



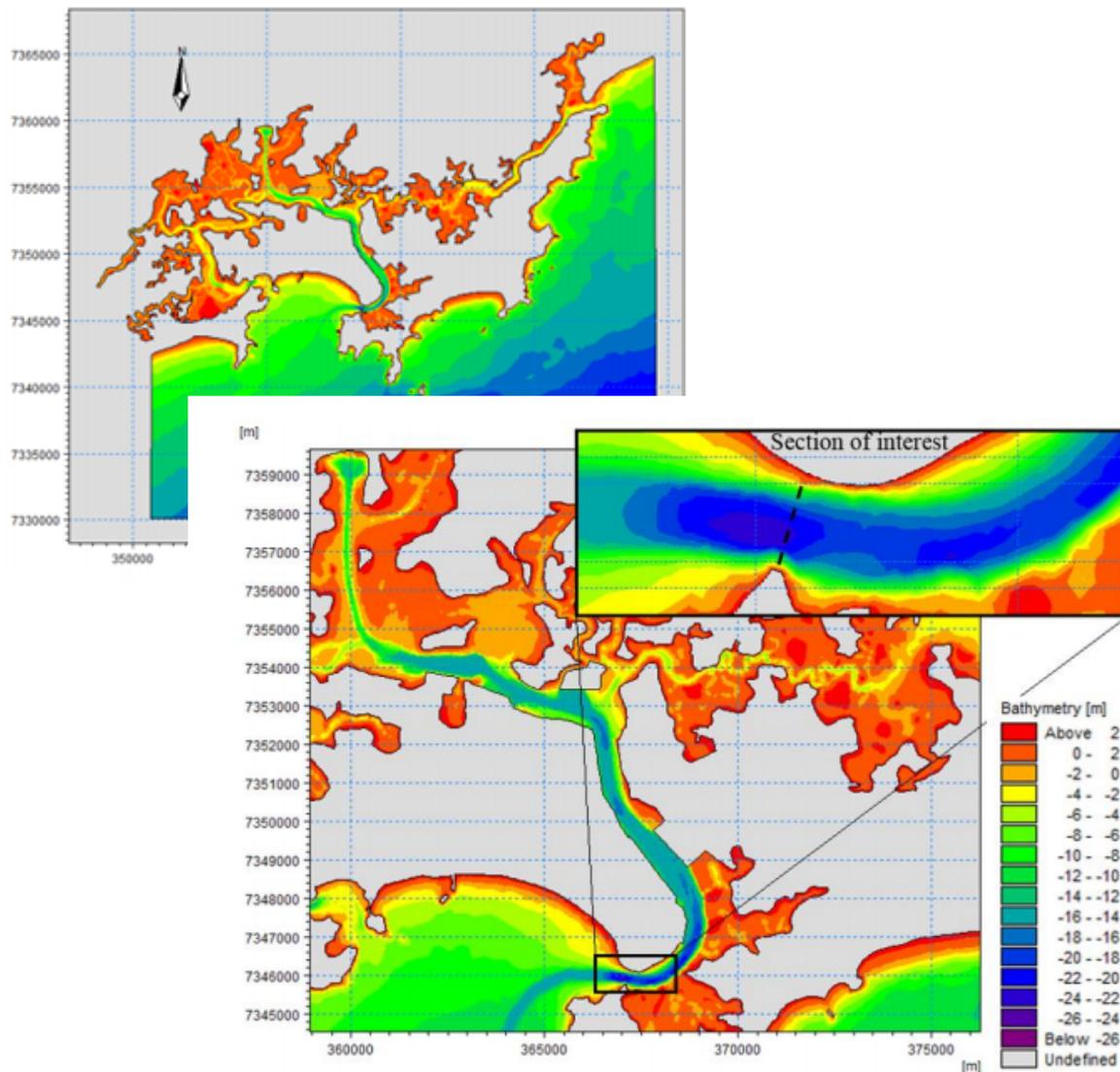
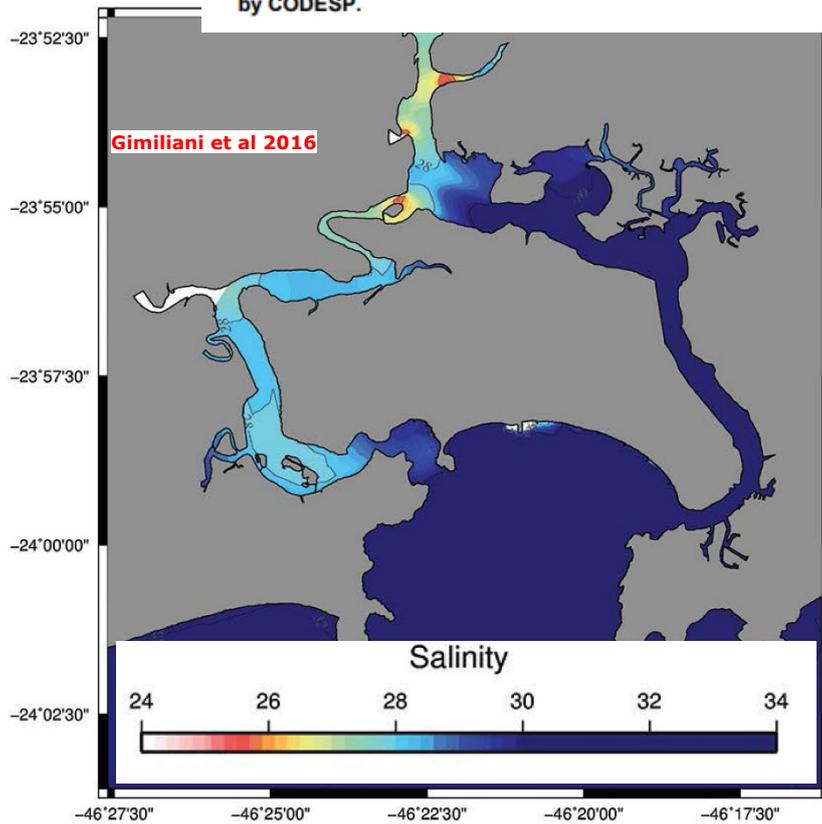


Figure 10 - Port of Santos channel bathymetry in the Santos estuary, data from 2014 conceded by CODESP.



The field trip will take approximately 4h, and we will visit the following points:

1. Start point: in front of Saldanha da Gama Club (lower Santos estuary);
2. Navigation along the Santos channel up to the Piaçaguera channel (inner estuary);
3. Way to the submarine emissary (Santos Bay);
4. Get around the island Urubuqueçaba;
5. Way to the Palmas Island.

REFERENCES

Souza et al. Historical records and spatial distribution of high hazard PCBs levels in sediments around a large South American industrial coastal area (Santos Estuary, Brazil). *Journal of Hazardous Materials*, vol 360, 15 October 2018, Pages 428-435

Campuzano et al. Integrated coastal zone management in South America: A look at three contrasting systems. *Ocean & Coastal Management*, volume 72, February 2013, Pages 22-35